A Dosimetric Comparison of Lung Treatment Plans Using High Definition MLC and Standard MLC

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INTRODUCTION

Stereotactic Body Radiation Therapy (SBRT) is a treatment modality that delivers high doses to the target volume in few fractions. The improvement in radiation beam shaping and advancement in imaging led to interest in the reduction in number of fractions for the whole treatment. Not only because of the highly conformal delivery to the target, but also the very high dose gradient to spare normal tissue adjacent to the target.

- Multileaf collimators (MLCs) are employed to shape the beam to the target.
- In TrueBeams, the two MLC types available are the high definition (HD) MLC (2.5 mm leaf width) and the normal MLC (5 mm leaf width) for the first 10 cm X 10 cm field size.
- Field size and width of the individual leaves determine the conformity and steepness of the dose gradient.

FIG 1.TruebBeam Linac

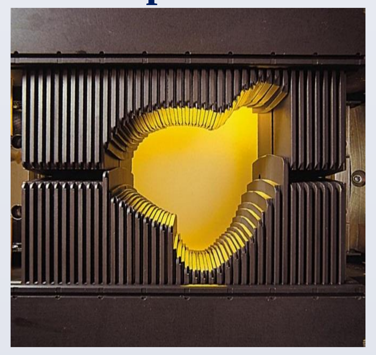

FIG 2.Regular 5mm MLC

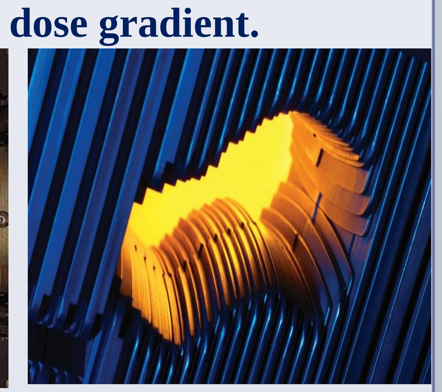

FIG 3.2.5 mm HD MLC

PURPOSE

- To study the significance of the differences between HD MLC and 5mm MLC in treatment planning
- To introduce methods to minimize these differences via optimization procedures.

MATERIALS & METHODS

A retrospective study of 25 patients cases who had been treated with SBRT were selected. The plans were chosen from two different cancer centers with TrueBeams (one with HD-MLC and the other with the 5 mm MLC).

New plans were generated by using the type of MLC that was not used in the original plan keeping the same optimization parameters.

The plan normalization for the newly generated plans were kept the same with the original plan for comparison.

The data from the cumulative DVH were exported to an excel sheet. Dose and volumes of planning treatment volume (PTV) and critical organs (lungs, esophagus, heart, spinal cord, trachea, and ribs) for the 50 plans were entered in an excel sheet for the analysis.

The homogeneity of the dose distribution, gradient indices and the conformity indices were evaluated for each of the plans.

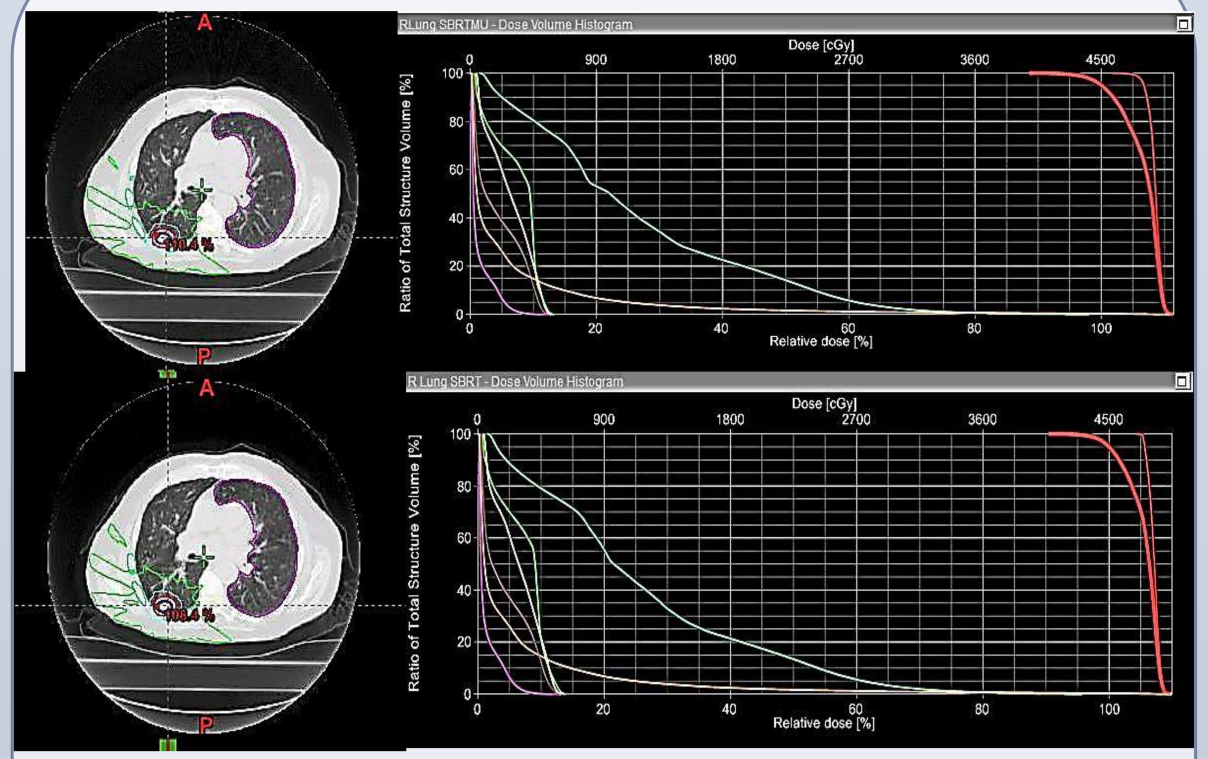

FIG 4. Images showing the isodose lines and corresponding DVH , upper with normal 2.5 mm MLC and the lower one with HD MLC

The conformity index is calculated from :

$$CI_P = \frac{V_{PTV} \times V_{PIS}}{(PTV_{PIS})^2}$$

V_{PTV} is planning target volume

V_{PIS} is volume encompassed by prescription isodose surface

PTV_{PIS} is planning target volume encompassed within the prescription isodose surface.

The heterogeneity index is: $HI = \frac{D_{max} - D_{min}}{D_{mean}}$

D_{max}, D_{min} and D_{mean} are respectively maximum, minimum and mean doses to the target volume.

These two indices are used to compare plans dosimetrically.

The treatment plans under consideration had been planned for 3-5 fractions with individual total dose variation from 35 to 60 Gy.

4 of the original plans had been delivered by Volumetric Modulated Arc Therapy (VMAT) and 21 by Intensity Modulated Radiation Therapy(IMRT).

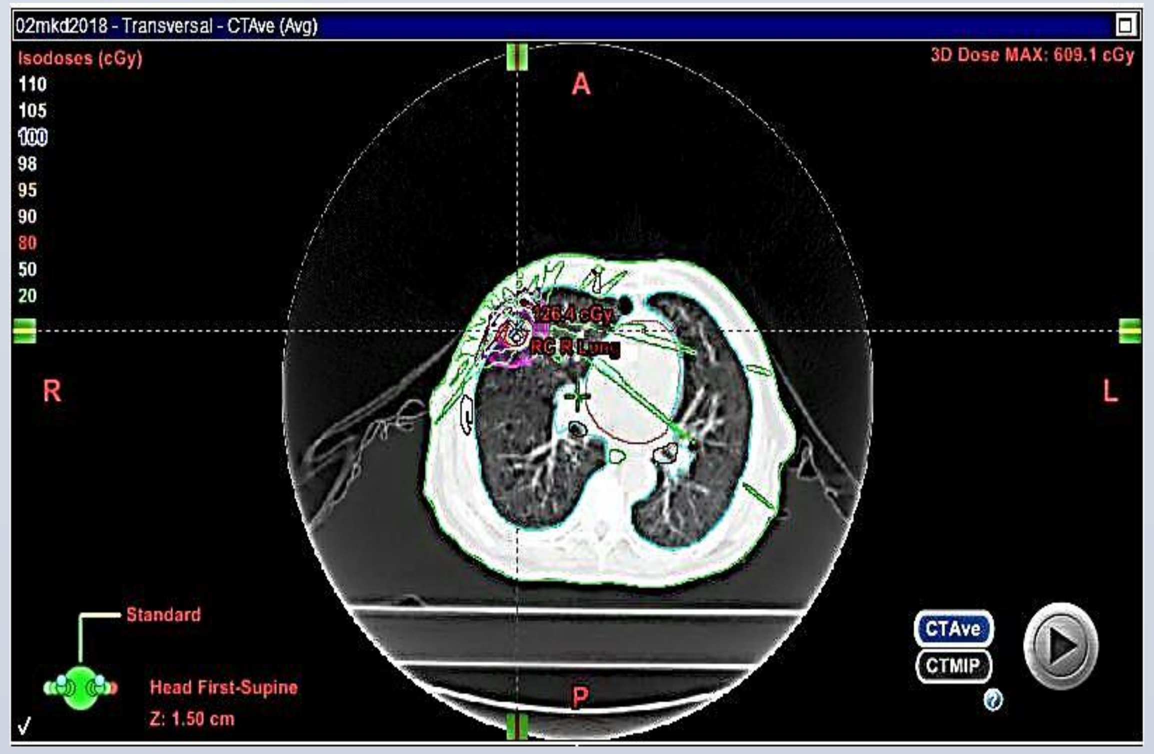

FIG 5. Example of plans difference (subtracting the total doses delivered form the 2 plans). Observe the difference of the isodose lines from the 2 plans.

RESULTS

Table 1. Conformity and gradient indices for Normal and HD MLC

Conformity Index		Gradient Index	
Normal MLC	HD MLC	Normal NLC	HD MLC
1.09	1.06	1.03	1.04
1.03	1.02	0.93	0.92
1.13	1.10	1.05	1.15
1.11	1.07	1.22	1.25
1.15	1.11	1.13	1.16
1.05	1.04	0.93	0.96
1.04	1.02	1.03	1.04
1.07	1.03	1.43	1.39
1.13	1.13	1.26	1.3
1.17	1.14	1.28	1.29
1.02	1.02	0.93	0.95
1.12	1.11	1.68	1.71
1.15	1.12	1.41	1.45

Conformity Index values decreased, or remained same for HD MLC compared to the Normal for all the plans. The mean decrease value for HD MLC is 2.02% (maximum is 6.79%).

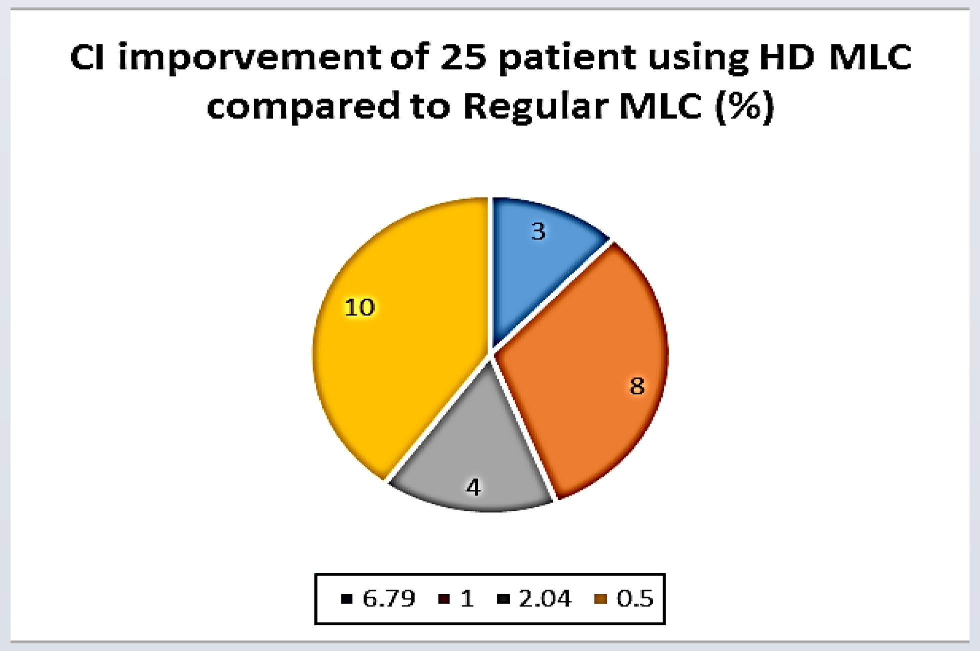

FIG 6. The conformity improvement for the 25 plans using HD MLC as compared to the Normal MLC .

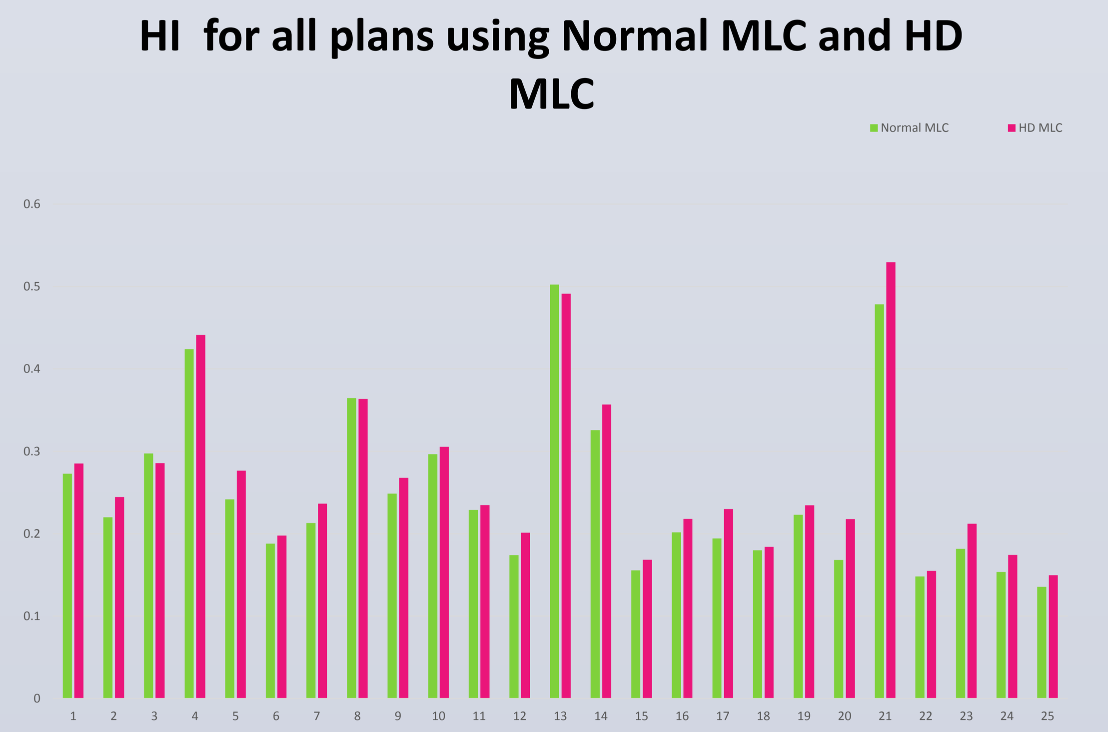

FIG 7. Heterogeneity indices for all plans using Normal MLC and HD MLC

The dose heterogeneity index (HI) values increased or remained same, except for two plans. The mean value of the increase is 6.65% for HD MLC (maximum increase 18.31%).

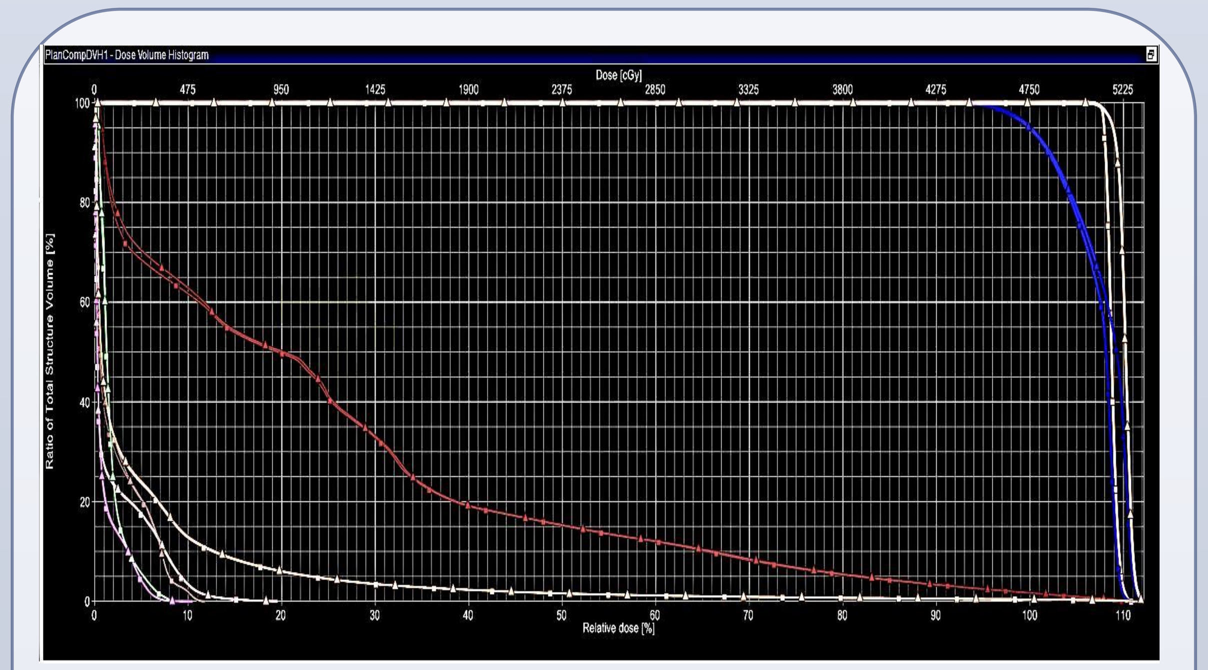

FIG 8. Plan comparison DVH which shows variation in Dose Volume with Normal MLC and HD MLC

CONCLUSION & FUTURE WORK

- This dosimetric evaluation of the treatment plans indicates that plans with HD MLC have dosimetric merit over the plans with normal 2.5mm MLC. However, the improvement degree is not consistent for all the plans.
- The radiobiological effect factor must be evaluated to conclude the advantages of the HD over the normal MLC.
- Optimization with changing parameters when using normal MLC can give the same dosimetric results as the HD MLC.
- We will evaluate the biological effective dose (BED), the equivalent uniform dose (EUD), the tumor control probability (TCP) for lung lesions, and the normal tissue complication probability (NTCP) for the healthy lung and the surrounding healthy tissues of each plan to compare the radiobiological effects.

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